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INSIGHTS FROM MATHEMATICAL MODELING IN SOVIET MISSION ANALYSIS (Part II)

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Research Report No. 86-6

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EXECUTIVE SUMMARY

In the late 1960s, Soviet analysts developed an exchange model for evaluating strategic nuclear forces based on the ratio of equivalent megatonnage remaining to each side after an initial strike. This model, the "correlation of nuclear forces," fits within the Soviet tradition of measuring the military balance in terms of ratios of "forces and means," and captures the essence of Soviet strategic thinking. This includes the importance of targeting and rapidly destroying an enemy's nuclear forces and war making potential as opposed to an effort to "punish" an adversary by targeting population centers. In addition, this analytic tool provided Soviet military planners with an "objective" basis for evaluating the balance of strategic forces, a tool they had apparently lacked prior to the late 1960s.

In order to test the potential influence and role of this model in Soviet strategic force planning, a number of alternate force structures were developed and certain parameters (alert rates, penetration rates, and silo hardness) were subjected to sensitivity analyses. It was determined that, of the possible Soviet options, the actual Soviet force structure was one of the best when evaluated according to the correlation of nuclear forces model. When SALT constraints were imposed on the Soviet force, other dominant alternative force structures were eliminated and the actual force was apparently the maximizing alternative.

It was also found that the actual force structure selected by the Soviets gave the advantage to whichever side struck first. In other words, if the US were first to strike, the Soviets would find themselves at a significant disadvantage as a result of the current force mix. The

Soviets could have selected other force mixes that would have reduced the US advantage -- but chose not to. This (coupled with the low alert rates maintained by Soviet strategic forces) suggests that the Soviets do not fear a US "bolt from the blue," but expect that, in the event of war, Soviet leaders will be able to accurately gauge the nature and course of the war and, if necessary, be the first to successfully employ strategic nuclear strikes.

The attacker's advantage, however, is contingent to a considerable degree on the adversary's alert posture, and in this the United States has the advantage. With the vast majority of Soviet EMT based on ICBMs, an increase in Soviet alert rates on SLBMs and in bombers would represent only a marginal increase in the Soviet EMT and correlation. On the other hand, an increase in the US alert or on station rates would substantially improve the US position, as the US ICBM force comprises a much smaller fraction of its total EMT. Similarly, the use of the correlation of nuclear forces model also helps explain continued Soviet devotion of resources to the air defense mission, despite Soviet vulnerability to missile attack.

The correlation of nuclear forces model suggests that the most efficacious area in which to concentrate Soviet breakout-related research is that of counter-SSBN anti-submarine warfare (ASW). Further ICBM improvements by the Soviets increasingly reap only marginal gains, as more and more US survivable EMT is deployed in submarines. A major Soviet breakthrough in strategic ASW, according to this model, could significantly change the correlation to the Soviet benefit.

PROJECT OVERVIEW

The objective of this project is to examine and assess the extent to which U.S. military policy has effectively interpreted and responded to the military implications of Soviet weapons innovations. The project focuses on the contributions of Soviet weapons innovations to military mission performance, not changes in the technological level of Soviet weaponry. It also examines the ability of the Soviet weapons innovation process to offer a militarily significant breakout option.

Accordingly, three related lines of inquiry are being pursued. First, we are examining the Soviet approach to weapons innovation as it is portrayed in their force planning and weapons evaluation literature. This initial work enables us to better understand the preferences, assumptions, and biases that influence the armaments selection process (and hence the weapons innovation process) in the Soviet Union.

Second, we are analyzing the Soviet approach to measuring the relative contributions of weapons innovation efforts towards improving mission capabilities, and not the extent to which a given piece of hardware can outperform the previous technological generation. Assessing mission contributions involves comparing quantities of arms and interaction with other weapons systems assigned to the given mission, as well as the qualitative characteristics of new weaponry.

Third, we are assessing the degree to which the Soviets have the capacity for "breakout" -- significantly improving their military capabilities in a short period of time -- through weapons innovation. The threat of a Soviet "technological surprise", in particular, has been

a constant U.S. fear.

Part I of this report addressed one aspect of the second task described. How do the Soviets use mathematical models to measure the impact of weapons innovations? Specifically, it examined the role that mathematical modeling plays in Soviet military analysis and some of its applications in the area of air defense analysis. In this second part of the report, we take a closer look at Soviet mathematical modeling related to notions of strategic technology innovation and strategic force development from their efforts to measure the nuclear balance?

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Contents

1.0 SOVIET STRATEGIC FORCE DEVELOPMENT

"Objective" measures of the intercontinental nuclear balance are already quite common in the West. Throw-weight, aggregate megatonnage, aggregate equivalent megatonnage, counter military potential, numbers of launchers, and numbers of warheads are just a few of the many indices used to gauge the nuclear balance. In contrast -- and as expected -- the Soviets have been reticent about detailing how they measure the nuclear balance, relying on generalizations about the current state of "parity."[1]

Certainly, static measures are used by the Soviets to define the strategic environment in a general sense. In SALT I, for example, the Soviets sought an imbalance (in their favor) in numbers of launchers as compensation for certain perceived US advantages. In SALT II, the Soviets agreed to do away with such inequalities. In fact, Soviet military writers frequently refer to what they call the "correlation of military forces" as a central measure of relative combat capability between two opposing sides. When dealing with conventional warfare, the correlation of military forces is presented as a comparison of ratios of friendly military means to enemy military means. This can be tanks to tanks, artillery to artillery, aircraft to aircraft, personnel to personnel, etc. Such correlations are considered objective indices of relative combat power and seem to figure prominantly in Soviet military assessments. So at least in this respect, there is some similarity between elementary approaches in the East and the West.

Static measures, however, are the simplest and probably the least

useful way to assess military balances, for they say nothing about the relative capabilities or vulnerabilities of the hardware being counted. Analytically, they provide no indication of how forces might be used or what result might emerge from their use. As described in Part 1 of this report, by the mid 1960s Soviet military planners began to recognize the importance of dynamic analysis for force posture planning and armaments selection. In particular, dynamic analysis meant the use of mathematical models to evaluate weaponry, examine command and control, and study combat engagements.

In this respect, initial Soviet efforts to measure the correlation of nuclear forces with simple ratios of "nuclear charges" (EMT) proved unrewarding. But it was from this conceptual basis that General-Major Anureyev proposed a dynamic measure of the correlation of nuclear forces. Anureyev argued that such a model could play an important role in strategic planning and force analysis. For several reasons discussed below, not the least of which was Anureyev's continued prominence in Soviet military analysis at the General Staff Academy during the 1970s, we believe that this model holds particular significance for understanding Soviet military thinking on assessing the nuclear balance.

In examining this correlation of nuclear forces model, this paper will first describe the setting in which it was developed: Soviet strategic thinking after 1953, the developing Soviet strategic force and thoughts on their use, and the threat perceived by Soviet planners. Then the model itself will be considered: how it reflects Soviet thinking and what it measures. The model will next be used to examine the changing correlation of nuclear forces from 1965 through 1984, at five year intervals, to provide a series of "snapshots" of the evolving

correlation. These results will be compared with a number of possible courses not chosen, in an effort to assess how well the model might serve as a guide to actual procurement practices and to determine if actual procurement policy has been in line with what one would expect had the Soviets been maximizing the correlation. Finally, the implications suggested by the model will be addressed.

1.1 Evolution of Soviet Strategic Thinking

Soviet military thinking had concluded after the Second World War that the offensive was the key to success, and that this offensive was to be waged against the enemy's forces. The Soviets rejected Western ideas of "strategic" bombing of the enemy's industrial capabilities or cities in order to weaken the enemy internally. Instead, destroying the enemy's forces would sufficiently weaken both the enemy's ability to damage the Soviet Union as well as his will to continue the war.[2]

With Stalin's death in 1953, Soviet military thinking was freed of the straitjacket imposed by his personal theory of the "Permanently Operating Factors" which he alleged led to victory in war. More significantly, the Soviet military could finally address the important political and military questions raised by the development of nuclear weapons. That same year, the United States sent the first nuclear weapons to Europe, and the Soviet Union tested its first thermonuclear weapon. The Soviet leadership thus had to address both the threat posed by American nuclear weapons as well as the military and political potential that nuclear weapons provided to the Soviet Union.

With the development of nuclear weapons, the importance of the offensive increased in Soviet thinking. Nuclear weapons, because of

their potential to rapidly alter the course and outcome of a battle or even a war, became the primary targets for the Soviet offensive. But Soviet ability to take advantage of its own developing nuclear potential was limited by geography (the Soviets could not counter the deployment of US nuclear weapons in Europe with an analogous deployment in the western hemisphere, at the time lacking allies in comparable proximity to the US) and technology (it lacked a meaningful intercontinental delivery capability).

But these limitations were not to last. The Soviet Union had captured a number of German rocket scientists at the end of World War II, and, based on their work, was able to deploy missiles first similar to the V-2 and, in 1955, a medium range ballistic missile (MRBM) of Soviet design -- the SS-3. While at the time, missiles were expected to be very inaccurate, thermonuclear charges were potentially able to compensate with their large yield for the inaccuracy of the delivery system.

The simultaneous development of nuclear warheads and the missiles capable of carrying them -- the "Revolution in Military Affairs" -- led to a sweeping reappraisal of military doctrine and military art by the Soviet military leadership. As one Sovet author noted,

> "The first thing to become obvious was the discrepency between such a powerful weapon as the nuclear bomb and the old delivery vehicle for this bomb, the airplane . . . , which was vulnerable to air defense weapons. A totally new delivery vehicle was needed."[3]

It was decided that missiles, due to their high speed, invulnerability to counter-measures, and all-weather capability, were the the most effective way to make use of nuclear weapons.

Nuclear-armed missiles made it possible to completely reverse the traditional route to victory in war. Prior to the Revolution in Military

Affairs, victory was acomplished through first achieving a number of low level victories. Such tactical successes led to operational ones, which in turn led to strategic and finally political victory. Through the use of nuclear missiles, Soviet specialists considered it possible to jump immediately to strategic successes, which would both facilitate operational and tactical successes at the lower level and speed a more rapid final political victory.[4]

Strategic targets were defined as those whose capture or destruction could bring about a rapid change in the course and outcome of the war. According to Soviet authors, these were, in order of importance:[5]

1. The enemy's nuclear forces, including launchers and air and naval bases, and associated C^3.
2. Other major groupings of forces, such as concentrations of conventional forces, and associated C^3.
3. Nodes of military and political control.
4. Military-industrial facilities, such as war materiel plants.

This hierarchy of targets has continued to this day. Only the Soviet ability to attack and destroy them has changed with time.

1.2 The Soviet ICBM Program

When the Soviet "Rocket Forces of Strategic Designation" (RVSN) was founded in 1959, its principle mission was to counter the US bomber threat by destroying US and allied airbases. As the threat to the Soviets shifted in character from bombers to missiles, the requirements changed as well: weapons capable of destroying smaller, "point" targets such as missile silos were required. Unable to achieve the accuracy required, Soviet planners emphasized large-yield weapons for a

counter-silo capability, while simultaneously developing smaller weapons for the purpose of destroying softer targets.

The deployment of a large SS-11 force (about 1000 missiles) also served to increase the number of targets that would have to be countered by the US in the event of an attack, stretching US capabilities to the point at which it would not be capable of destroying all, or even most, of the Soviet force. (This idea of a "strategic sponge" reappeared in the United States in the late 1970s as the Multiple Aim-Point System for the MX missile, in which there would be simply too many targets for an attacking force to destroy.) This, of course, changed with the deployment of MIRVs on ICBMs by the United States, which began in 1970. The Soviets were apparently frustrated by the desire to both preserve their own capability to develop MIRVs as well as to limit US MIRVing.[6] They recognized the threat posed to their force by US MIRVing of land-based missiles, and it became clear that the sheer size of their force would no longer ensure its survivability. The correlation of nuclear forces threatened to shift against them.

2.0 MEASURING THE CORRELATION

As was noted, Soviet targeting has a distinctive hierarchy in which enemy nuclear forces are first priority. The US has attempted to keep its ICBM force one step ahead of a Soviet threat since the late 1950s, hardening the silos to withstand first 25 then 300 psi pressure and dispersing them, then providing for alternative launch control centers and further hardening the silos. This effort has recently taken on new importance with the completion of the deployment of the fourth generation of Soviet ICBMs, which are seen as threatening the US ICBM force. This has resulted in a number of well-known proposals for protecting the new MX ICBM, among them mobile launchers, multiple protective systems, "deep-basing," and "dense-pack" or cluster-basing.

The pursuit of survivable basing is driven by the belief that the Soviets have a theoretical ICBM capability with which they can threaten to destroy the US ICBM force while maintaining a reserve sufficient to devastate the rest of the US. Taking the ICBM balance alone, some have argued that the US deterrent is no longer credible and requires repair through the development of a force capable of threatening the Soviet ICBMs in a similar fashion, while protecting US weapons.

But these scenarios are based on strategic analysis that appears to be at variance with Soviet military thought. The only publicly known Soviet methodology for measuring the strategic intercontinental balance seems to be one published in the June, 1967 issue of the Soviet General Staff's classified journal, Military Thought.[7] The article, written by General Major I. Anureyev of the General Staff Academy, argues that the

correlation of nuclear forces is made up of a number of intangible factors such as command skill and the "moral-political" factor, but that a rough measure can be derived by calculating the deliverable EMT remaining to each side after an initial strike. In other words, the correlation of nuclear forces reflects the ratio of soft area target destruction potential each side possesses at a given point in time during a nuclear conflict. Hard target destruction is only one part of the measure.

As noted earlier, the correlation of nuclear forces is consistent with a long tradition of Soviet thinking about warfare. Since the "Great Patriotic War" with Nazi Germany, Soviet planners have examined the correlation of military forces in various battles by ratios, first of equipment (eg, tanks vs. tanks), and, more recently, of firepower.

The novel aspect of the Anureyev model is that it is a <u>dynamic</u> model. Rather than simply looking at the <u>pre-conflict</u> balance of forces, measured by launchers, warheads, or EMT, it requires that assumptions be made about how a war would be waged and how those forces might be used. In addition, it allows for differentiation in the <u>capabilities</u> of forces, something that is lost in static measures.

Anureyev suggested that the model might be especially useful for planning the actions of forces.[8] The article, and that which followed in response to Anureyev, make it clear that

> the method used by General Major I. Anureyev with some additions can be used successfully in calculating the correlation of nuclear forces in nuclear weapons for operations on a large scale and also for planning a first nuclear strike as well as for accomplishing other specific missions.[9]

The clear implication is that targeting to maximize the post attack correlation of nuclear forces is the proper planning strategy. The

corollary, not explicit in the text, is that _if_ the correlation might be used to plan actual military operations, it might also be used to guide procurement.

The precise place of the Anureyev model in Soviet strategic planning is unclear. Some months later, Anureyev's article was criticized in several letters by other members of the General Staff Academy, but these critiques focused on the simple structure of the model -- many complex factors are subsumed in only a few variables.[10] There was no attack on the fundamental logic of the model.

We suspect that the underlying concepts of the model do reflect Soviet military thinking on strategic force analysis, even if the precise formulation offered by Anureyev is not used today. For reasons discussed in Part I, it is likely that Soviet military art and military science were built into the foundation of Anureyev's work. Thus, it may well capture the fundamental tenants of Soviet strategic thinking.

2.1 The Correlation of Nuclear Forces

The correlation of forces is a familiar concept to readers of Soviet military journals, as it is often used in assessing the results of specific engagements in World War II. While the correlation is never characterized as decisive, for that would leave no room for human variables such as skill or "moral-political" factors, it provides an important opportunity to the side with the advantage.

Two nuclear forces are assumed: A, with I different types of delivery vehicles, and B, with J different types of delivery vehicles. The following formulae are then used:

$Q_{iA} = \sum_i [r_i n_i][(q_i)^{2/3}]$ = equivalent megatonnage (emt--that is, the yield of the warhead to the 2/3 power) in the i-th type weapon for side A.

$Q_{jB} = \sum_j [r_j n_j][(q_j)^{2/3}]$ = equivalent EMT in the j-th type weapon for side B.

r_i (or r_j) = number of warheads of i-th (or j-th) type weapon for side A (B).

n_i (or n_j) = number of i-th (or j-th) type weapon for side A (B).

q_i (or q_j) = yield in megatons of one warhead for the i-th (j-th) type weapon.

The total EMT for each side ($\sum Q_{iA}$ or $\sum Q_{iB}$) is represented by Q_A or Q_B.

At time t-o, ie, prior to any exchange, λ_o is merely the ratio

of EMT: $[Q_A]/[Q_B]$.

$\lambda_T = \lambda_{T-1} \cdot \alpha$ = correlation of nuclear forces at time T (side A attacks; side B defends).

α = ratio of <u>relative change</u> in the distribution of forces between the two sides as a result of A's attack on B.

$$\alpha = \frac{\sum (F_{iA})(W_{iA})(R_{iA})(U_{iA})}{\sum (F_{jB})(W_{jB})(R_{jB})(U_{jB})}$$

$F_{iA} = [Q_{iA}]/Q_A$ at t_o $\qquad$ $F_{jB} = [Q_{jB}]/Q_B$ at t_o.

W_{iA} = warhead penetration capability of i-th type weapon of side A.

W_{jB} = warhead penetration capability of j-th type weapon of side B.

R_{iA} = reliability of i-th type weapon.

R_{jB} = reliability of j-th type weapon.

U_{iA} = percentage of i-th type weapon not consumed in attacking B.

V_{jB} = percentage of j-th type weapon not destroyed in attack by B.

Table 1: Soviet ICBM Characteristics*

for Selected Years

Missile	Year	# RVs	Yield/ RV (mt)	EMT/ missile	CEP (nm)	Reliability
SS-7	1965	1	3	2.1	1.5	.5
	1970	1	6	2.3	1.25	.5
SS-8	1965	1	3	2.1	1.0	.5
	1970	1	5	2.9	1.0	.5
SS-9	1970	1	25	8.5	.75	.8
	1975	1	25	8.5	.5	.8
	1980	1	25	8.5	.5	.8
SS-11	1970	1	1	1	1.25	.8
	1975	1	1	1	.8	.8
	1980	1	1	1	.8	.8
SS-13	1970	1	1	1	1.0	.8
	1975	1	1	1	1.0	.8
	1980	1	1	1	1.0	.8
SS-17/1	1975	4	.75	3.3	.24	.85
	1980	4	.75	3.3	.24	.85
	1984	4	.75	3.3	.24	.85
SS-17/2	1980	1	6	3.3	.23	.85
SS-18/1	1975	1	25	8.5	.23	.85
	1980	1	20	8.5	.19	.85
SS-18/2	1980	8	.9	7.4	.23	.85
SS-18/4	1984	10	.5	6.3	.14	.85
SS-19/1	1975	6	.55	4.0	.19	.85
	1980	6	.55	4.0	.14	.85
SS-19/2	1980	1	5	2.9	.21	.85
SS-19/3	1984	6	.55	4.0	.14	.85

*Soviet ICBM characteristics are difficult to judge and often presented with an artificial precision. In addition, (see next page)

2.2 Running the Correlation Model

To examine how the correlation has changed over time, simulated exchanges were run for 1965, 1970, 1975, 1980, and 1984 using the actual force structures for both the Soviet Union and the United States. The model run assumes a full scale attack involving the entire range of intercontinental forces: ICBMs, bombers, and SLBMs, as well as strategic defense such as SAMs. In addition, several hypothetical Soviet force structures were developed, with a different mix of forces in 1970, 1980, and 1984. There was also one alternative US case, in which the Minuteman II force (450 missiles) was replaced with Minuteman III missiles (as the Soviets expected to take place), and several variations on US bomber penetration capability. For each case, actual and hypothetical, the correlation was examined after both a US and a Soviet first strike.

The CoF model specifies targeting to maximize enemy reliable EMT destroyed -- that is, a target's priority was based on its EMT and reliability. Bomber and submarine forces on alert were assumed to survive owing to their mobility; soft targets such as air and naval bases were targeted by SLBMs, while ICBMs, the only forces capable of countering hard targets effectively, were generally used against enemy ICBMs. [For details of the forces, see Appendix A]

(*continued) they are based on a sometimes small number of samples and from tests taking place in artificial conditions. Yields and CEPs are taken from declassified intelligence estimates and public sources such as IISS and Aviation Week. Reliability, perhaps the most difficult parameter about which to obtain "hard" data, is here set somewhat arbitrarily and based on the assumption that Soviet reliability is a bit lower than that of US ICBMs. There are reports, however, that Soviet ICBM reliability is much lower than that of the US.

The results of the running of the correlation are shown in Table 2, and graphically in Figure 1.

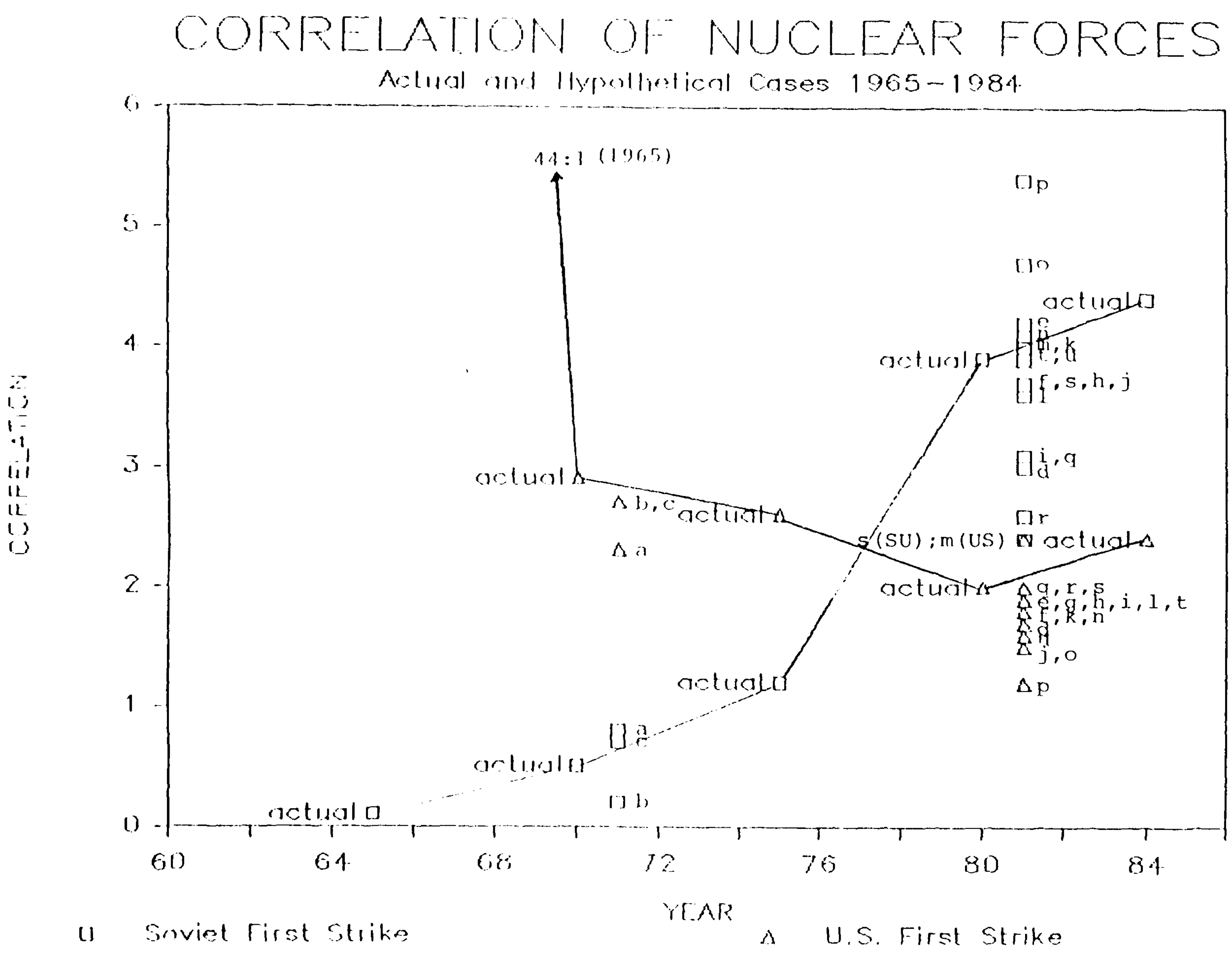
Clearly, the position of the Soviet Union has improved dramatically over time. The reasons are clear: since 1975, the Soviet ICBM force has increased its EMT, as the SS-17 (with 3.3 EMT/missile), SS-18 (with 6.3 - 8.5 EMT/missile), and SS-19 (with 2.9 - 4 EMT/missile) replace the older and less reliable SS-11 (with only 1 EMT) and SS-9 (with 8.5 EMT). These new missiles (in particular, the SS-18 and SS-19) have substantially improved the capability of the Soviets to destroy US ICBM forces in their silos. Simultaneously, the new Soviet ICBMs have been hardened from 300 psi to a reported 2500 psi, making them less vulnerable to a US strike.

Table 2: Actual Correlations of Forces

Attacking country	correlation of forces after attacker's first strike 1965	1970	1975	1980	1984
United States	44.0	2.9	2.6	2.0	2.4
Soviet Union	.1	.5	1.2	3.9	4.4

The correlation of nuclear forces is the ratio of the attacker's deliverable EMT to that of the enemy after a first strike. Thus, a correlation of 2.9 in 1970 means that after a US first strike, the US would retain 2.9 times the reliable, deliverable EMT as held by the Soviets. Similarly, a correlation of .5 suggests that the Soviets, after launching a first strike in 1970, would have about one-half the deliverable EMT available to the US.

Several hypothetical cases were also considered for the years 1970 and 1980. To do so, cost estimates were used for the ICBMs involved, and the total Soviet expenditure for the missiles involved was calculated. Then the number of missiles were varied, keeping the level of



CORRELATION OF NUCLEAR FORCES
Actual and Hypothetical Cases 1965-1984
CORRELATION
YEAR
44:1 (1965)
actual
s(SU);m(US)
□ Soviet First Strike
Δ U.S. First Strike

expenditures constant [see Appendix B]. This approach made it possible to hypothesize different force mixes within an assumed cost ceiling (dictated by the actual force). For all but one case, only two types of missiles were varied in each hypothetical case, with the remainder of the force remaining constant, ie, that actually deployed. (The results of all the hypothetical cases are shown in Table 3.) For 1970, four such cases were examined:

(A) 1500 SS-11s and no SS-9s
(B) 460 SS-9s and no SS-11s
(C) 100 SS-9s and 1190 SS-11s

As can be seen from the graph (Figure 1) and Table 3, the resulting correlations for the Soviet attack would have been on either side of that actually chosen. In the event of a US attack, the option selected by the Soviets, it seems, was the best for the <u>United States</u> -- initially a puzzling result. Interestingly, a force made up completely of SS-11s would have been the best for the Soviets from the defensive perspective. This suggests several possibilities. First, the Soviets may not have been very concerned about a US first strike, to the point of allowing the US an advantage. After all, the US did not attack the Soviet Union during the 1950's when US strategic superiority could have ensured a successful disarming first strike. Likewise, the US failed to use nuclear weapons against China during the Korean war, even though US military doctrine seemed to prescribe it. A second possibility is that the SS-9 either served a purpose other than attacking ICBMs or that the Soviet planners were confident that it would be able to counter US ICBM launchings. There is evidence that the SS-9's were actually targeted against US ICBM launch control centers (LCCs). If the Soviets assumed that the destruction of a given LCC would disable several ICBM launchers,

then this alternative targeting would have made sense. It is also possible other factors led them to deploy the SS-9 force as they did, such as a desire to deploy more than one ICBM design as a hedge against technological risk. Then, too, the decisions about SS-9 and SS-11 procurement were made before the correlation of nuclear forces model and the attendant mode of thinking gained any influence (if it ever did). This last possibility is supported to some extent by the timing of the Anureyev article (mid-1967), which was probably part of a campaign to inject objective analysis into Soviet thinking about nuclear war. As detailed in Part I, initial efforts were undertaken beginning in the second half of the 1960s to develop a systematic approach to weapons acquisition and development.

It is the hypothetical 1980 cases, however, that prove more interesting. These were:

variations of the SS-17 and SS-19 force

(D) 560 SS-17s and no SS-19s
(E) 410 SS-19s and no SS-17s
(F) 665 SS-19s and no SS-17s and no SS-18s
(G) 225 SS-17s and 225 SS-19s
(H) 280 SS-17s and 205 SS-19s

variations of the SS-18 and SS-19 force

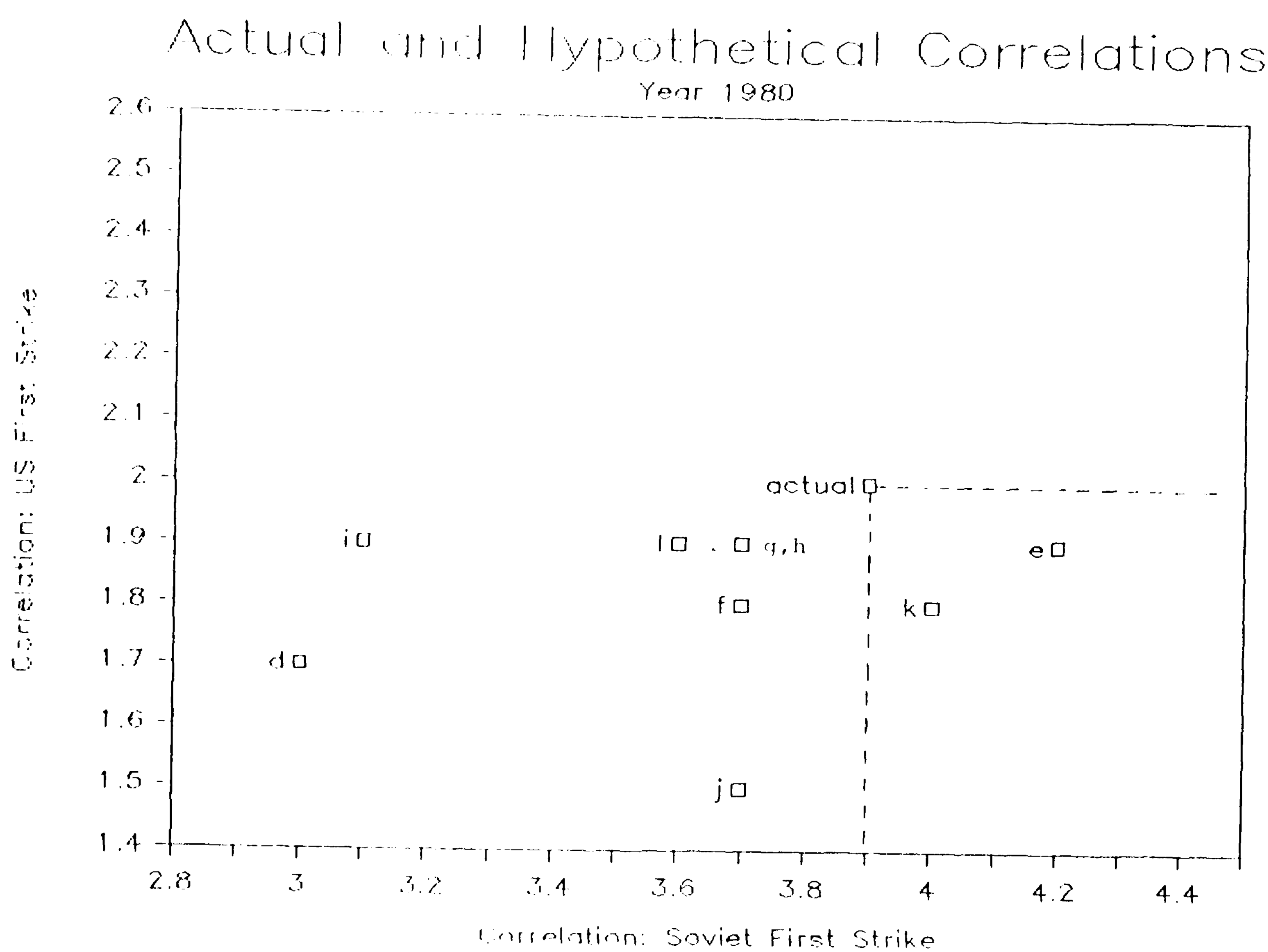
(I) 510 SS-18s and no SS-19s
(J) 750 SS-19s and no SS-18s
(K) 150 SS-18s and 550 SS-19s
(L) 410 SS-18s and 150 SS-19s

variation in the US force

(M) 1000 Minuteman IIIs and no Minuteman IIs

variations in US bomber penetration and alert rates

(N) 75% penetration
(O) 50% penetration
(P) 25% penetration
(Q) US bombers at 50% alert
(R) US bombers at 67% alert
(S) US bombers at 75% alert



Actual and Hypothetical Correlations
Year 1980
Correlation: US First Strike
Correlation: Soviet First Strike
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
actual
i
l
g,h
e
f
k
d
j

variations in Soviet submarine alert rates

(T) 25% of Soviet SSBNs out of port
(U) 50% of Soviet SSBNs out of port

Variations in the Soviet ICBM forces were based on estimated Soviet expenditures for ICBMs. The capabilities of the missiles remained constant; only relative deployment quantities were varied, and then only for two missile systems (with the exception of case F). In devising these alternative force mixes, SALT II constraints were ignored, because potential Soviet achievements are the focus of this study.

The first fact apparent from figure 1 is that by 1980 the positions of the United States and the Soviet Union had reversed. The relative correlation of nuclear forces shifted in favor of the Soviet Union around 1977, when the advantage to the Soviets of striking first surpassed that to the United States. The meaning of such a measure, however, is unclear. Both the United States and the Soviet Union gain the advantage by being the first to strike, but since about 1977, the relative advantage shifted in favor of the Soviet Union.

What is more interesting, however, is that the force posture which the Soviets actually selected, while not the apparent maximizing solution, is dominant within the constraints of SALT and manipulating only ICBM forces. Among the solutions that would promise a better correlation in the event of a Soviet first strike (E, K, N, O, and P), one -- K -- would have required a violation of the SALT II agreement (more MIRVed missiles than was to be allowed). N, O, and P would have required the devotion of significantly greater resources to the Air Defense Forces. Only option E, the 410 SS-19/no SS-17 force, would have provided a better correlation by manipulating only the ICBM force but

without violating any agreements and that E was not chosen may reflect several possibilities. The need to maintain the design bureau responsible for the SS-17 (the Yangel bureau), or the bureau's influence on the decision-making apparatus (Yangel's bureau is located in Dnepropetrovsk, a favored region under Brezhnev's regime) should be considered. Moreover, the desire to avoid placing all the Soviet technological eggs in only one or two new systems has always been an important factor in Soviet procurement policy. The spreading of technological risk means that no single design would carry the total burden of innovation. Given the differences in warhead loading and accuracies, it can safely be assumed that SS-17 and SS-19 have different "front ends." Obviously, the SS-17 front-end design did not match up to the SS-19 design. Or perhaps the decision and retooling to begin production of the SS-17 (which had begun flight-testing seven months before the SS-19) had been made too soon, and the deployment of 150 served in part to justify the development expenses. SS-17 performance simply failed to match expectations (<u>or</u>, SS-19 performance surpassed expectations).

Given uncertainty in the estimates of Soviet weapons characteristics, sensitivity analysis shows that within error limits, the existing Soviet force structure in 1980 may actually be the maximizing mix. It should also be noted that the SALT process appears to have had an impact on the Soviet strategic programs. Acceptance of the SALT II limits bounded any improvement in the correlation of nuclear forces.

The option selected by the Soviets, however, is not without its drawback: it allows the United States to obtain its best possible correlation of nuclear forces through first strike as well, with one

exception. The exception would, however, require US, not Soviet action: the full MIRVing of the US Minuteman force. In other words, the mix selected by the Soviets reflects a tolerance for maximized US correlation in the event the United States launches a first strike. In return, the Soviet correlation is also high if the Soviets strike first. Of course, this trade-off is acceptable if the Soviet political and military leadership is reasonably certain that the Soviet Union will be the one to go first in a nuclear conflict.

As demonstrated by the 1984 data, the time trend of correlation of nuclear forces begins to flatten out for the Soviets in the 1980s, while the position of the US increase marginally. The Soviet position has shifted with the completion of its deployment of SS-17, SS-18, and SS-19 ICBMs. <u>The result is a Soviet strategic force whose preemptive capability is about as good as is attainable within existing technological, economic. and political constraints</u>. This fits well with Soviet discussions of how a nuclear war should be waged. Soviet leaders appear willing to allow the United States a very high correlation of nuclear forces under a US first strike scenario, in exchange for a very high correlation in the event the Soviets decide, and are able, to strike first. This suggests that the Soviets do not ascribe a high likelihood to a US "bolt out of the blue."

Table 3: Summary of Correlations For

Actual and Hypothetical Force Postures

Case	Mix	Correlation of Forces: US attacks first	Correlation of Forces: SU attacks first
1965	Actual 1965	0.1	44.0
1970	Actual 1970	2.9	.5
A	1500 SS-11s, no SS-9s	2.4	.8
B	460 SS-9s, no SS-11s	2.7	.2
C	100 SS-9s, 1180 SS-11s	2.7	.7
1975	Actual 1975	2.6	1.2
1980	Actual 1980	2.0	3.9
D	560 SS-17s, no SS-19s	1.7	3.0
E	410 SS-19s, no SS-17s	1.9	4.2
F	865 SS-19s, no SS-18s, no SS-17s	1.8	3.7
G	225 SS-17s, 225 SS-19s	1.9	3.7
H	280 SS-17s, 205 SS-19s	1.9	3.7
I	310 SS-18s, no SS-19s	1.9	3.1
J	750 SS-19s, no SS-18s	1.5	3.7
K	150 SS-18s, 530 SS-19s	1.8	4.0
L	410 SS-18s, 150 SS-19s	1.9	3.6
M	1000 MM III, no MM II	2.4	4.0
N	75% US bomber penetration	1.8	4.1
O	50% US bomber penetration	1.5	4.7
P	25% US bomber penetration	1.2	5.4
Q	US bombers at 50% alert	2.0	3.1
R	US bombers at 66% alert	2.0	2.6
S	US bombers at 75% alert	2.0	2.4
T	25% of Soviet SSNs out	1.9	3.9
U	50% of Soviet SSNs out	1.6	3.9
1984	Actual 1984	2.4	4.4

Table 3: Summary of Correlations For

Hypothetical Force Postures (cont'd)

Case	Mix	Correlation of Forces: US attacks first	Correlation of Forces: SU attacks first
1984	75% US bomber pen Sov. silos @ 2500* psi	1.8	4.1
V	50% US bomber pen Sov. silos @ 2500* psi	1.4	4.7
X	25% US bomber pen Sov. silos @ 2500* psi	1.1	5.4

*Hardness of the SS-17, SS-18, and SS-19 silos; the hardness of the SS-11 and SS-13s are considered to be 1000 psi.

3.0 CONCLUSIONS AND IMPLICATIONS

Anureyev's correlation of nuclear forces model -- taken as a conceptual framework rather than as an explicit algorithm -- is intriguing because of some of the insights it may offer into innovation decisions in Soviet strategic force planning. In particular, the Anureyev model produces a dynamic measure of the nuclear balance that integrates strategic offense and strategic defense. The fact that the actual Soviet force posture appears to have maximized the correlation of nuclear forces, as opposed to other measures such as RVs, suggests that perhaps this is the tool used by the Soviet planners, or that it may serve as a useful analogue for either the model they do use or their thought process.

If this measure captures the essence of Soviet assessments of the nuclear balance, then it should also provide useful insights into their perceptions of breakout threats and opportunities.

3.1 Implications of the Model

If the model, or its fundamental structure, serves as a guide to planning, then Soviet strategic targeting should place a premium on the destruction of the enemy's EMT, as opposed to the destruction, for example, of the enemy's RVs. None of Anureyev's critics suggested that there was an error in the EMT emphasis in the model.

The model is open-ended: each additional equivalent megaton serves to improve one's position. This factor may serve as an incentive to the continued retention of systems that appear obsolete. The SS-7 and SS-8,

although vulnerable and of questionable reliability, provided 10 to 15% of the Soviet EMT until they were withdrawn in the late 1970s. Moreover, they would have required the US to expend some of its own forces to destroy them. In addition, the model's emphasis on the ratios of survivable EMT serves as a stimulus to fractionate one's missiles. The MIRVed versions of the SS-17, SS-18, and SS-19 have greater total EMT (as well as flexibility and efficiency in the use of force) than their single-RV models.

But Anureyev's model fails to give guidance as to sizing of forces, except in relation to an adversary. The correlation value itself is a ratio, and tells little about the utility of the forces remaining to each side. A correlation of 2 could be 2 EMT to 1, 200 to 100, or 2 million to 1 million. As a result, the index alone gives no natural ceiling at which the "curve" of the correlation might flatten out, and thus no concept of "sufficiency" independent of the enemy's capabilities. The size of the force is driven by that of the adversary, as each attempts to improve the ratio of forces. In this respect, the correlation of nuclear forces model is a true "EMT" arms race model, in that it pushes each side to try to better the ratio.

Of course, this is true in the non-nuclear models of the correlation of forces as well, and Soviet planners, based on their analysis of conflicts, have determined certain ratios as desirable. For example, tanks in the defense can generally defeat two to three attacking tanks, while a successful tank offensive requires a four or five to one tank advantage. The "optimum" ratio desired for nuclear forces is unknown (if, indeed, one exists at all), but given the destructive potential of even a few nuclear weapons, it might be expected to be large.

Because deliverability of the EMT is another major factor, the survivability and defense of Soviet forces is important as well. This includes both passive measures (such as silo-hardening) as well as active (such as anti-aircraft systems).

Reliability, alert rates of non-hardened forces, penetration capabilities, and the fraction of the entire EMT concentrated in a given weapon system are treated in the model as being of equal value. Thus, the same results could be achieved by improving a weapon's reliability, its penetration, by shifting EMT from a vulnerable to a survivable system, or simply by putting a larger fraction of the force on alert. That the Soviets have not strived to put a greater fraction of the SLBM and bomber forces on alert may reflect technical constraints, or simply that they do not expect a "bolt from the blue" by the United States. Or it may reflect a decision to continue concentrating EMT into the ICBM force, the most capable, easily controlled, and, apparently, cost-effective method for the delivery of Soviet nuclear weapons.

3.2 Strategic Offense

The Anureyev model produces a scenario dependent measure of the strategic balance. That is to say, assumptions about the characteristics and phasing of nuclear employment of both sides affects the results. This is in contrast to static measures, which are scenario independent. Thus, if the Anureyev model does reflect the Soviet military approach to assessing the nuclear balance, then their perceptions of

- -- the viability of their strategic posture
- -- new strategic force requirements
- -- the danger posed by US strategic programs

will depend heavily on the scenarios they use to structure their contingency planning.

In this respect, our analysis of the Anureyev model using actual and alternative Soviet strategic force data shows that the Soviets chose not to pursue seemingly equal-cost ICBM force structures that could have reduced the American preemptive threat. While this may seem surprising in light of the constant barrage of Soviet propaganda regarding US plans for a first strike, there is other evidence of lack of Soviet concern. Soviet strategic bombers have never been placed on air or ground alert. Until the mid-1960s, warheads for Soviet strategic missiles were kept separate from the missiles. Until the introduction of Soviet fourth generation ICBMs in late 1974 and 1975, only a relatively small fraction of Soviet ICBMs were kept on an alert posture.[12] Soviet SSBNs have maintained very low on-station alert rates -- 10% to 20%. While there may be good explanations for these anomolies, the fact remains that had the Soviet leadership's top strategic priority been to reduce their vulnerability to a US first strike, there were many things they could have done to decrease significantly that threat. The low level of day-to-day alert that characterized the Soviet military posture through the 1960s and 1970s -- from the Strategic Rocket Forces to the Air Defense Troops -- suggests confidence that they will have the time to move to a generated alert posture.

In the context of a generated alert, our analysis of the Anureyev model suggests that the focus of Soviet military efforts has been to maximize their own preemptive potential (under the correlation of forces rubric), while acting under certain technological, organizational, and external constraints. Their ICBM innovation and deployment activities --

as reflected by the model -- suggest that, should the Soviet leadership perceive that war is imminent, they are reasonably confident that they will have the option to preempt. Three distinct missions are implicit in the Anureyev model:

- -- offensive strikes against enemy strategic forces (with priority with priority weighting by EMT or ability to destroy Soviet residual EMT),
- -- active defense against second (and subsequent) retaliatory strikes,
- -- and follow-on offensive strikes against enemy economic-industrial capabilities.

The "counter-EMT" offensive strike is targeted, first and foremost, against US bomber and ICBM bases and their associated C^3. Also targeted are SSBN facilities and related C^3. Systems requirements for attacks against bomber bases, SSBN bases, and C^3 facilities are prompt, large-EMT strikes of modest accuracy. Soviet ICBMs have had this capability since the late 1960s (SS-9 and SS-11 ICBMs). Systems requirements for attacks on ICBM silos are prompt moderate EMT strikes of high accuracy. These requirements were not approximated until the deployment of the fourth generation Soviet ICBMs; specifically, the SS-18 and SS-19. For the most part, there is little need to consider innovation surprise of breakout possibilities here, as the fundamental capability already exists in the deployed force.

The single area of weakness in the offensive mission involves action against US SSBNs. Up to the present, US SLBMs have held only about 20% of the US EMT and they have had no real capability to threaten Soviet large-EMT systems: Soviet ICBMs. Soviet targeting priorities dictated by the Anureyev model would imply that blunting US SLBM capabilities should have been the lesser concern in comparison to countering US bombers and ICBMs. And there does not seem to have been much Soviet activity in

counter-SSBN operations in the past. However, forthcoming changes in the US SLBM force -- specifically Trident I and II -- should increase greatly the significance of countering US SSBNs under the correlation of nuclear forces framework. Trident II will hold substantial EMT and will directly threaten Soviet large-EMT systems. (By 1990, the EMT carried on US SLBMs will increase by 90% (from about 700 to about 1350).) It follows that capabilities to detect, track, target, and destroy US SSBNs should grow increasingly important to Soviet military planners and are areas where innovation surprise and breakout could make a significant difference.

Areas conducive to technological innovation leading to breakout (see Report #1) would be in SSBN detection and tracking. Such activities could involve a relatively small number of systems that could be custom made, rather than mass produced (though this is not necessarily the case). Thus, it is possible that if the Soviets could develop the technology, they might not be hampered by the usual engineering and production hurdles that historically have constrained the development of operational capabilities based on technological innovation. One area would be the space-based synthetic aperture radar designed for submarine detection and tracking. However, significant technological innovations would be required in sensors, automated control systems, and computers -- none of which are strong Soviet technology areas. Such innovations would take a long time to develop and would require extensive testing -- though most of it would not be readily apparent from observation.

Technological innovation would not be required for the destruction activity. Building on prior Soviet systems, design innovation and application innovation would provide suitable capabilities for the rapid destruction of SSBNs, given that they could be localized. Since Soviet

military production capabilities are at their strongest when "new" products reflect design innovation, a fairly rapid breakout in destruction potential could be made.

In sum, the area of greatest significance with respect to breakout in the counter-EMT offensive strike mission is the counter-SSBN task. On the one hand, many onerous technological innovations are required to support the detection, localization, and tracking activities in technology areas where the Soviets have demonstrated considerable weakness. Very long development times can be expected, but short production to initial operating capability times. On the other hand, only design and/or application innovations will be needed to develop the capability for destruction given localization. Here, moderate production to initial operating capability times can be expected, given the quantitative production demands.

3.3 Strategic Defense

Strategic defense has a prominent role in the correlation of nuclear forces concept in general, and in the Anureyev model in particular. The Soviets have concentrated efforts in active strategic defense in three areas: air defense systems, antiballistic missile systems, and anti-space systems. (In the mid 1960s, this subdividing of the strategic defense mission was mirrored in the structure of the National Air Defense Forces, which was composed of an anti-air defense command, an anti-missile defense command, and the anti-space defense command. There is no open source information pertaining to the continuing existence of these commands.) The Anureyev model deals explicitly with only the anti-air and the anti-missile missions. While one might implicitly factor the

anti-space mission into the model (Anureyev did a considerable amount of work on space weaponry), it is not a direct part of the analysis.

3.3.1 The Anti-Air Mission

The role of the air defense in the Anureyev model is, of course, to reduce the enemy's EMT delivered by aircraft and cruise missiles. Many western experts have wondered why the Soviet military continued and continues to spend a substantial portion of their military resources on strategic air defense when their country is completely vulnerable to many thousands of missile-delivered warheads. While many possible explanations have been advanced -- organizational and bureaucratic inertia, a national fortress mentality, strategic concerns over third parties, etc. -- the correlation of nuclear forces model adds an analytic rationale. Even after the introduction of ICBMs, more than 50% of the US strategic EMT continued to be held in its bomber force. Thus, under the Anureyev formulation, the US strategic bomber force would be weighted very heavily.

As described above, this translates first into priority targeting in the initial counter-EMT offensive strike. Active air defense, then, is expected to reduce the residual US bomber-held EMT. That is to say, given apparent Soviet expectations that they will have the benefit of the preemptive strike, the Soviet air defense system will most likely engage a significantly reduced US bomber threat. Therefore, relatively small improvements in the Soviet air defense "barrier" produces relatively large changes in the nuclear correlation of forces as measured by the Anureyev model. It follows that the cost-effectiveness of the Soviet air defense system may look more reasonable within this framework.

Since EMT is a surrogate measure for lethality to soft area targets, the Anureyev model suggests that strategic air defense would be most effectively concentrated in a zone defense for protecting economic-industrial assets. (This assumes, in line with Soviet writings on the subject, that soft military targets (for example, airbases and ground force concentrations) are targeted in the initial strike.) This agrees with doctrinal statements that the primary task of the Troops of the Anti-Air Defense (the new name of the National Air Defense Forces) is to protect and preserve the potential of the economic-industrial base of the USSR. Soviet possibilities for technological, design, or application innovation leading to breakout should, therefore, be assessed in the context of this specific mission.

Part I of this report looked at the air defense mission and so there is no need to repeat the analysis here. However, it should be emphasized that the question of Soviet air defense innovation and breakout will revolve around the struggle against low observable (and low altitude) targets. This is a change that the Soviet military has already recognized, as is reflected in the recent reorganization of the Air Defense forces. It follows that special emphasis is likely to be placed on detection and tracking technologies (sensors and processing) and automated control systems. Again, from the perspective of the Anureyev model, the task is to reduce further US surviving air-breathing EMT.

3.3.2 The Antiballistic Missile Mission

Our general observations about Soviet interest in the ABM mission follows along a line similar to that of the air defense mission. Western discussions of the ABM usually talk in terms of two missions: defense of

missile sites (ballistic missile defense) and defense of economic-industrial zones. Under the correlation of nuclear forces rubric, following the initial counter-EMT offensive strikes, the balance is assessed in terms of relative threat to each side's soft target array. Ballistic missile defense -- ie, the protection of Soviet ICBMs -- does not contribute to the correlation of nuclear forces in this respect, unless one allows that the US strikes first. But as we have already seen, this does not seem to be the Soviet assumption. Thus, missile site defense would not appear interesting to Soviet military planners within this strategic framework.

The Soviet ABM mission, as reflected in the Anureyev model, is oriented towards protection of soft area targets: economic-industrial zones. This does affect the "balance" as the correlation of nuclear forces' framework measures it. Similar to the air defense mission, the ABM mission is to reduce the residual (following the Soviet first strike) US missile delivered EMT. The explicit expectation of the model is synergy between the strategic offense and strategic defense missions.

Very marginal improvements in the ABM mission could be made by design and application innovations on air defense systems. It should be clearly understood, however, that the Anureyev model weighs strongly against diverting air defense assets (which can significantly affect the correlation of nuclear forces) for marginal improvements in ABM capability. Therefore, even a marginal ABM breakout involving design and application innovation would require the rapid deployment of very large stocks of covertly stored equipment beyond that required for the air defense mission.

Design innovation on existing ABM systems could enhance Soviet ABM

capabilities, but even a marginal breakout would demand the covert production, testing, and storage of large quantities of equipment. Medium- and long-term equipment storage is practiced in the Ground Forces and Troops of Anti-Air Defense, but often produces reliability problems.

A truly significant ABM breakout capability, as defined by the Anureyev model, will require a number of simultaneous technological innovations. The reason is that US missile-held EMT is dispersed among many thousands of independently targetable reentry vehicles. This is especially true of the SLBM force, which is currently the least vulnerable to Soviet counter-EMT offensive strikes. The first series of technological innovations will have to be in the areas of detection, tracking, and discrimination. Here again, we are talking about sensors and computers. Automated control systems are emphasized by Soviet military specialists.

The second series of technological innovations will have to be in kill mechanisms. Technological innovations for non-exotic kill systems -- nuclear explosives, kinetic energy "missiles", mesh umbrellas, etc. -- will have to be implemented on a quantitatively large force. While this is a technology area well within Soviet science and engineering capabilities, production may be a bottleneck (due to quality control). The extensive geographic requirement for non-exotic ABM kill systems means that full operational breakout deployment is likely to take a considerable amount of time, and be highly observable.

Technological innovations in exotic kill systems -- lasers, particle beams, rail guns, etc -- will place much greater demands on Soviet science and engineering capabilities. Space-based systems would be the most demanding of all and, we believe, are very far beyond Soviet

capabilities. Requirements for miniaturization, reliability and operational longevity, automated control, and onboard sensing, processing and computing, are all areas where the Soviets have experienced continuous failure without exception. (To some extent, these hurdles could be lessened by a manned weapons platform.) Ground-based exotic ABM kill systems, while still representing onerous technological barriers, are much more consistent with Soviet science, engineering, and production capabilities.

3.4 Follow-on Strategic Offense

This mission involves the potential strikes against economic-industrial targets. While our presentation suggests phasing in time, Soviet military strategy does not preclude that the counter-EMT and counter-value strategic offensive strikes might occur simultaneously. However, Soviet military thinking is also consistent with the notion that a very high post- (counter-EMT) strike correlation of nuclear forces could deter the enemy from launching retaliatory counter-value strikes. This would spare major segments of the economic-industrial base of both countries.

Significant breakout in this mission (beyond existing capabilities) could be attained without any technological innovation. Design and application innovation could provide the basis for a very large covertly deployed ICBM force assigned to counter-value targeting. This would be a very reliable and potent force, since it would represent minor design improvements on long-deployed systems.

3.5. A Final Observation

Western strategic thinking attempts to distinguish between "good"

and "bad" strategic weapons. Good strategic weapons are defined as those that enhance deterrence and without threatening strategic stability. In general, these are weapons that do not create incentive for either side to adopt a launch on warning posture -- ie, either weapons that are slow (bombers and cruise missiles) or weapons that cannot threaten the strategic forces of the other side with a prompt disarming first strike (current SLBMs).

If the Anureyev model does reflect accurately the Soviet approach to measuring the correlation of nuclear forces, then it is readily apparent that their strategic thinking does not make this distinction. The concept behind the Anureyev model integrates the counterforce and countervalue threats. As such, extensive deployments of highly MIRVed heavy ICBMs do not take on the intensely negative connotation often attributed to them in Western strategic thinking.

Appendix A:

Assumed Forces

Because force characteristics change over time, it was necessary to adjust the numbers as well as technical capabilities of weapons systems for each year examined. These represent estimates from a variety of sources, and some (especially reliability) are subject to wide variations.

It should also be noted that this study uses the Soviet EMT calculation, in which all yields are raised to the 2/3 power, unlike the US calculation, in which yields above 1 mt are raised only to the 1/2 power.

System	Number	RVs/system	emt/RV	Rel.	Pen.	CEP (nm)	F*
			Soviet Systems				
1965							
SS-7	199	1	2	.5	1	1.5	.36
SS-8	23	1	2	.5	1	1.0	.04
Bison	56	1	2.9	.5	.7	na	.15
Bear/b	35	1	2.9	.5	.7	na	.09
Bear/m	75	1	1.6	.5	.9	na	.11
1970							
SS-7	190	1	3.3	.5	1	1.25	.15
SS-8	19	1	2.9	.5	1	1.0	.01
SS-9	228	1	8.5	.8	1	.75	.47
SS-11	770	1	1	.8	1	1.25	.19
SS-13	30	1	1	.8	1	1.0	.01
Bison	56	1	2.9	.5	.7	na	.04
Bear/b	35	1	2.9	.5	.7	na	.03
Bear/m	75	1	1.6	.5	.9	na	.03
SS-N-6	224	1	.8	.75	1	1.0	.04

*F is the fraction of EMT on a given weapon system.

System	Number	RVs/system	emt/RV	Rel.	Pen.	CEP (nm)	F
1975							
SS-7	186	1	3.3	.5	1	1.25	.11
SS-8	19	1	2.9	.5	1	1.0	.01
SS-9	276	1	8.5	.8	1	.5	.44
SS-11	840	1	1	.8	1	.8	.16
SS-13	60	1	1	.8	1	1.0	.01
SS-17/1	10	4	.83	.85	1	.24	.01
SS-18/1	32	1	8.5	.85	1	.23	.05
SS-19/1	50	6	.67	.85	1	.19	.04
Bison	56	1	2.9	.5	.7	na	.03
Bear/b	35	1	2.9	.5	.7	na	.02
Bear/m	70	1	1.6	.5	.9	na	.02
SS-N-6	528	1	.8	.75	1	1.0	.09
SS-N-8	150	1	.9	.75	1	.84	.03
1980							
SS-9	30	1	8.5	.8	1	.5	.05
SS-11	460	1	1	.8	1	.8	.08
SS-13	60	1	1	.8	1	1.0	.01
SS-17/1	130	4	.83	.85	1	.24	.08
SS-17/2	20	1	3.3	.85	1	.23	.00
SS-18/3	26	1	8.5	.85	1	.19	.04
SS-18/2	282	8	.93	.85	1	.23	.33
SS-19/1	270	6	.67	.85	1	.14	.18
SS-19/2	30	1	2.9	.85	1	.21	.02
Bison	43	1	2.9	.5	.7	na	.03
Bear/b	38	1	2.9	.5	.7	na	.02
Bear/m	75	1	1.6	.5	.9	na	.02
SS-N-6	436	1	.8	.75	1	1.0	.06
SS-N-8	292	1	.9	.75	1	.84	.05
SS-N-18	160	3	.3	.7	1	.76	.03
1984							
SS-11	520*	1	1	.8	1	.8	.09
SS-13	60	1	1	.8	1	1.0	.01
SS-17/3	150	4	.83	.85	1	.24	.09
SS-18/4	308	10	.63	.85	1	.14	.34
SS-19/3	360	6	.67	.85	1	.14	.26
Bison	43	1	2.9	.5	.7	na	.02
Bear/b	38	1	2.9	.5	.7	na	.03
Bear/m	75	1	1.6	.5	.9	na	.02
SS-N-6	368	1	.8	.75	1	1.0	.05
SS-N-8	292	1	.9	.75	1	.84	.05
SS-N-18	224	3	.3	.7	1	.76	.04

*The number of SS-11s available for intercontinental missions is assumed to have increased with the deployment of the SS-20.

US Systems

System	Number	RVs/system	emt/RV	Rel.	Pen.	CEP (nm)	F
1965							
T-II	59	1	4.3	.75	1	.7	.06
MM-1	795	1	1	.8	1	1.0	.20
B-52	630	4	1	.9	.85	na	.63
A-1	80	1	.9	.6	1	.5	.02
A-2	208	1	.9	.85	1	.5	.05
A-3	176	3 (MRV)	.34	.9	1	.5	.04
1970							
T-II	54	1	4.3	.75	1	.7	.06
MM-1	490	1	1	.8	1	1.0	.12
MM-2	500	1	1.1	.85	1	.3	.13
MM-3	10	3	.3	.90	1	.18	---
B-52	517	4	1	.9	.85	na	.50
A-2	128	1	.9	.85	1	.5	.03
A-3	512	3 (MRV)	.34	.9	1	.5	.13
C-3	16	10	.12	.9	1	.27	---
1975							
T-II	54	1	4.3	.75	1	.7	.07
MM-2	450	1	1.1	.85	1	.3	.14
MM-3	550	3	.3	.90	1	.18	.14
B-52	369	4/4	1	.9	.85	na	.41
FB-111	66	2/4	1	.9	.85	na	.06
A-2	48	1	.9	.85	1	.5	.01
A-3	208	3 (MRV)	.34	.9	1	.5	.06
C-3	400	10	.12	.9	1	.27	.13
1980							
T-II	54	1	4.3	.75	1	.7	.07
MM-2	450	1	1.1	.85	1	.3	.15
MM-3	450	3	.3	.90	1	.12	.12
MM-3/m	100	3	.48	.90	1	.1	.04
B-52	316	4/4	1	.9	.85	na	.36
FB-111	66	2/4	1	.9	.85	na	.04
A-3	80	3 (MRV)	.34	.9	1	.5	.02
C-3	416	10	.12	.9	1	.27	.15
C-4	80	8	.22	.9	1	.23	.04
1984							
T-II	35	1	4.3	.75	1	.5	.04
MM-2	450	1	1.1	.85	1	.2	.14
MM-3	250	3	.3	.90	1	.12	.06
MM-3/m	300	3	.48	.90	1	.1	.12

<u>1984</u> (cont'd)							
B-52	14	12 cm	.34	.90	.75	na	
		4 bmb	1				.33
B-52	258	4 bmb	1	.90	.75	na	
FB-111	66	2 bmb	1	.9	.85	na	.04
C-3	304	10	.12	9	1	.27	.10
C-4	312	8	.22	.9	1	.23	.16

Appendix B:

Soviet ICBM Costs

There are several different sources for estimates of Soviet ICBM costs, spanning almost 20 years. Unfortunately, the costs often seem incongruous, ie, the superior SS-18 apparently costs little more than the SS-9, produced 8 years previously.

Techniques

The only specific information available on techniques for estimating Soviet ICBM costs (of which I am aware) is contained in a 1964 study by the DoD (DDRS [78] 137), in which

> "It was found that the cost of Soviet ICBMs could be fit by ANW^k where A is \$10 M [million 1964 \$--PA] per 1 KP [kilo-pound -- PA] missile in inventory (\$12.5 M per reliable missile), N is the number of Soviet missiles, W is the payload per missile in kilopounds (KP), and k = .4."

Otherwise, the costs are generally presented in the aggregate, ie, the cost for the full deployment of ICBMs over a given number of years.

Estimates

The DoD method of ANW^k was applied in the DoD study to the SS-7, SS-8, SS-9, SS-10, and a hypothetical missile that resembles the SS-11. These gave the following results:

missile	A(m\$)	N	W(kp)	ANW[k]	AW[k]
SS-7	\$10		4		\$17.4
SS-8	\$10	23	4		\$17.4
SS-9	\$10	288	9.5		\$24.6
SS-11	\$10	1030	1.5		\$11.8

The second source of information is a series of hearings held in the early 1970s, in which Albert Wohlstetter testified on the cost-

effectiveness of the proposed ABM system. In his presentation, he compared three different estimates of the SS-9's cost, two classified and one unclassified. In addition, his comments suggested that the ten-year cost for the Minuteman was about $11 million in then-year dollars, and that the SS-11 ten-year cost exceeded that of the Minuteman by between two and three times.

While Wohlstetter did not reveal the details of the two classified studies, he did reveal enough about the ratios of costs of the classified studies to the unclassified costs of the ABM systems to make it possible to work backwards and approximate the classified estimates. Each gave the following:

Missile	Initial Investment	10 year cost
SS-9 triplet	$32-33 million	$47-50 million

The year for the dollar estimates was not given; however, from the context it appears likely that these are 1971 or 1972 dollars.

A New York Times article of roughly the same period (April 27, 1969, p. 8F) quoted intelligence sources as suggesting that the SS-11 cost was approximately $^{1}/_{4}$ that of the SS-9.

The final source for estimates of ICBM costs, and the only one of which I am aware that deals with the fourth generation SS-17, SS-18, and SS-19 ICBMs, is an article in the Congressional Record by Les Aspin (July 9, 1979). In it, Aspin includes a table (p. E 3453) comparing the counterforce cost effectiveness of the US and Soviet ICBMs, arguing that

the US capability is much more cost-effective. Citing a CIA Military Economic Analysis Center memo to him (June, 1979), Aspin quotes the following information:

"Cost of SS-17/-18/-19 ($3.75, $10.26, and $7.86 billion, respectively, through 1982, plus an additional $1 billion each year from then to 1985)..."

Aspin assumed that by 1982, 200 SS-17, 308 SS-18, and 312 SS-19, will be deployed. After calculating the cost/silo of operations and maintenance (O&M) of $1.2 million (ie, $1 billion divided by 820 silos) and the number of "missile-years" of each ICBM, it is possible to estimate the following costs, presumed to be in 1978$:

SS-17	$14 million
SS-18	$28 million
SS-19	$19 million

In addition, there are two other references that may be useful. In 1981, the HASC was told during its hearings on the Posture Statement (Book 2 of 2, Part 4 of 6; R&D) by Kelly Burke that if the Soviets repaclaced the SS-17 and SS-19 with a new missile with a higher MIRV count, it would cost $5.95 million per additional RV, and if unspecified "additional MIRVed ICBMs" were deployed in conjunction with a further fractionantion of the entire ICBM force, the cost/RV would be $3.85 million per additional RV.

The Senate Appropriations Commitee was also told in 1981 that the cost/RV to the Soviets was about $3.5 million.

SRF Budget data

Working from the CIA estimates of Soviet defense expenditures, it is possible to estimate SRF percentages of the Soviet defense expenditures:

1965	7.9%	1973	5.0%
1966	9.8%	1974	5.7%
1967	9.8%	1975	5.7%
1968	8.6%	1976	7.2%
1969	7.4%	1977	7.7%
1970	5.7%	1978	8.6%
1971	4.3%	1979	8.6%
1972	3.8%	1980	7.4%

Using similar data, it is possible to estimate the cost/RV for the Soviet ICBM, SLBM, and LRA forces for selected years, in millions of 1978$:

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
(a)	7.1	6.9	4.8	3.6	3.0	3.3	3.8	3.1	2.9	2.4
(b)	69.6	33.7	16.5	9.7	8.7	8.5	8.7	7.1	5.8	4.3
(c)	2.7	2.8	2.8	2.9	2.9	2.9	2.9	2.9	2.9	2.9

(a) is ICBMs
(b) is SLBMs
(c) is long range bombers

References for Appendix B

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Notes

1. Although in discussing nuclear weapons in Europe, they have relied on the number of launchers as the measure of parity, arguing that both NATO and the Warsaw Pact have almost 1000 nuclear armed bombers, missiles, and submarines allocated in Europe or for European targets.

2. For general discussions of the evolution of Soviet military thinking in the late 1950s, see Raymond Garthoff, Soviet Military Strategy in the Nuclear Age (New York: Praeger, 1958) and H.S. Dinerstein, War and the Soviet Union (New York: Praeger, 1962).

3. M. Cherednichenko, "Military Strategy and Military Technology," Military Thought, #4, 1973, p. 47.

4. See Nikolai Lomov, "Influence of Soviet Military Doctrine on the Development of Military Art," Communist of the Armed Forces, Nov., 1965, translated in W.R. Kintner and Harriet Fast Scott, The Nuclear Revolution in Soviet Military Affairs (Norman, Oklahoma: University of Oklahoma Press, 1968), p. 161; K.S. Moskalenko, "Raketnye Voyska na Strazhe Bezopasnosti Rodini" (Rocket Troops on Guard Over the Security of the Motherland), Krasnaya Zvezda, Sept. 13, 1961, p. 3; and Nikolai Krylov, "Raketnye Voyska Strategicheskogo Naznacheniye" (Rocket Troops of Strategic Designation), Voyenno-Istoricheskii Zhurnal, #7, 1967, pp. 16-23.

5. For a quick review of Soviet targeting, see the CIS SSSWG research memo by Peter Almquist "Strategic Targeting and the Soviet RVSN." For Soviet examples and discussion, see K.S. Moskalenko, "Raketnye Voyska na Drazhe Bezopasnosti Rodini," Krasnaya Zvezda, September 13, 1961, p. 2; S.S. Biryuzov, "Raketno-yadernoe Oruzhie i Boevaya Gotovnost'," Krasnaya Zvezda, Dec. 4, 1962, p. 2; N.I. Krylov, "Strategic Rockets," translated in Walter Clemens, ed., World Perspectives on International Politics (Boston: Little, Brown, 1965) pp. 250-253; Krylov, "Raketnye Voyska Strategicheskogo Naznacheniya," Voyenno-istoricheskii Zhurnal, #7, 1967, pp. 15-23; Krylov, "The Nuclear Missile Shield of the Soviet State," Military Thought #11, 1967, pp. 13-21; and M. Cherednichenko, "Ob Osobennostyakh Razvitiya Voyennogo Iskusstva v Poslevoyennyy Period," Voyenno-istoricheskii Zhurnal, #6, 1970, pp. 19-30.

6. See Gerard Smith, Doubletalk: The Story of SALT I (Garden City, NY: Doubleday, 1980), chapter 4; and Raymond Garthoff, "SALT and the Soviet Military," Problems of Communism, #1-2, 1975, pp. 21-37.

7. I. Anureyev, "Determining the Correlation of Forces in Terms of Nuclear Weapons," Military Thought, #6, 1967.

8. Anureyev (1967), p. 243.

9. B. Khabarov, N. Bazanov, Ye. Orlov, and L. Semeyko, "Methodology of Determinig the Correlation of Nuclear Forces," Military Thought, #8, 1968, pp. 55.

10. Khabarov et al, p. 50-57.

11. This is the only hypothetical case in which numbers, not cost estimates, were used for sizing the force.

12. For information on the low Soviet alert rates maintained for ICBMs (a reported 25-30%), see Walter Pincus, "Debut of Soviet Missiles Could Color US, NATO Politics," The Washington Post, June 26, 1980, p. 2; and Aviation Week and Space Technology, June 25, 1979, p 22.